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ABSTRACT

This chapter argues for the value of sibling research in addressing behavioral genetic issues on the etiology of individual differences. The goal of the report is to provide a set of simple and practical examples of sibling analyses in order to highlight the importance of incorporating siblings in future research. It begins with a discussion of behavioral genetics and individual differences, and then proceeds to present five specific types of sibling analysis: (1) univariate sibling analysis, which estimates the importance of shared familial influences in development; (2) nonshared sibling analysis, which asks why siblings are so different; (3) developmental sibling analysis, which investigates the how the contribution of familial factors changes during development; (4) multivariate sibling analysis, which studies how familial factors overlap in influence on specific traits; and (5) DF sibling analysis, which examines familial links between the normal and abnormal. Contains 42 references. (SD)

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SIBLINGS, BEHAVIORAL GENETICS, AND COMPETENCE*

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Any topic in developmental research would profit from the study of siblings. For example, research on siblings has provided a new look at family processes (Dunn & Kendrick, 1982) and at social development (Dunn, 1988). The purpose of this chapter is to propose another reason to study siblings: They provide an entrée into behavioral genetic issues. One does not need to be a behavioral geneticist in order to address behavioral genetic research questions about the origins of individual differences in development. The most important behavioral genetic research will increasingly be conducted by researchers who are not behavioral geneticists, but rather by

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experts from substantive domains who use behavioral genetic methods to address theory-driven questions. Studying siblings is a first step in this direction.

Little can be lost and much can be gained by including siblings in developmental research. Including siblings does not prohibit asking any research questions of interest. In addition, data from a second child in each family can be employed for purposes of replicating research using a within-family comparison. The researcher can then step back and look at the topic from a new perspective that considers sibling similarities and differences.

The most obvious question concerns familial resemblance: How similar are siblings in the same family for a given phenomenon? Surprisingly, for many traits, siblings are dissimilar; this leads to the question of why siblings in the same family are so different. These are key issues in behavioral genetics. Other behavioral genetic questions are less obvious. Questions can be asked about developmental changes in sibling resemblance. Also, multivariate questions can be asked: Do familial or nonfamilial influences on one dimension or disorder overlap with such influences on another? Finally, sibling research can be used to address the critical issue of etiological links between the normal and abnormal. These five types of sibling analyses are examined in this chapter. We begin, however, with introductory discussions concerning behavioral genetics and individual differences.

Sibling analyses are familial rather than genetic. That is, resemblance between siblings can be due to genetic factors because siblings are first-degree relatives whose coefficient of genetic relatedness is .50. Sibling resemblance can also be due to shared environmental influence because siblings grow up in the same family. Studies of twins and adoptive siblings are needed to disentangle the relative contribution of nature and nurture to sibling resemblance. As a first step toward understanding the etiology of individual differences in development, studies of siblings are nonetheless valuable in documenting the importance of familial resemblance, regardless of its nature or nurture origins.

Although the focus of this chapter is on sibling analyses of familiality rather than twin and adoption analyses that disentangle nature and nurture, the logistics of disentangling genetic and environmental sources of familial resemblance are not as difficult as one might think. Approximately 1% of all births produce twins. Moreover, twins, and especially parents of young

twins, are particularly willing to participate in research because twins are perceived to be special. Even adoption designs are still possible. During the 1960s and early 1970s, approximately 1% of all births involved nonfamilial adoptions, and about one-third of adoptive parents adopted a second child (Mech, 1973). Although the numbers of such adoptions declined dramatically during the 1970s due to contraception and abortion, an adoption study of young adults, born in the 1960s and early 1970s, is possible. Moreover, recent increases in the number of stepfamilies affords the opportunity to estimate genetic influence by comparing full, half, and unrelated siblings (Reiss, 1993).

In this chapter, we discuss the value of sibling research in addressing behavioral genetic issues. Perceived competence is used throughout the chapter as an example of an area of developmental research that has only recently begun to be investigated using sibling as well as twin and adoption designs. The benefits of including siblings in developmental research can also be seen in this volume in the chapter on delinquency and IQ by David Rowe (Chapter 7).

INDIVIDUAL DIFFERENCES AND PERCEIVED COMPETENCE

Behavioral genetic research focuses on the investigation of individual differences within a species, not species-typical development. The behavioral genetic question is, why do some children perceive themselves, and are perceived by others, as more competent than other children? In contrast, much theory and research describes normative developmental stages of perceived competence. Although it is important to consider species-wide themes as well as variations on these themes (McCall, 1981; Scarr, 1992, 1993), it is also important to emphasize the distinction between these two perspectives. The processes involved in the development of individual differences can differ from the processes responsible for species-typical development. For example, the young of mammalian species require caregivers and form special relationships with them, a universal feature of our species and other mammals, which is surely the genetic result of evolutionary processes. There are, however, individual differences in attachment relationships within our species. These individual differences may be influenced by ge-

netic differences between infants or between caregivers, or they may be due entirely to nongenetic factors. In summary, behavioral genetic research addresses phenotypic differences among individuals in a population. Its goal is to ascribe phenotypic differences to genetic and environmental sources of variance. The theory and methods of behavioral genetics are presented elsewhere in overview (Plomin, 1990) and in detail (Plomin, DeFries, & McClearn, 1990).

Most behavioral genetic research continues to focus on cognitive abilities, personality, and psychopathology. Not coincidentally, these are the three domains of psychology in which individual differences have been most extensively studied (Plomin & McClearn, 1993). In contrast, little is known about the origins of individual differences in traditional areas of social development such as perceived competence. This lack of behavioral genetic research is due to the focus of social development research and theory on species-typical developmental themes rather than individual variations (Plomin, 1994). More specifically, theories of perceived competence tend to be normative theories, although some strands of empirical research in this domain have long considered individual differences (Harter, 1983).

There is a wide range of differences among children in how competent they perceive themselves, and are perceived by others, to be. Research is needed to describe, predict, and explain these individual differences. For example, why are some children so low in perceived competence? Moreover, as compared to normative questions, questions about individual differences are more amenable to research that goes beyond mere description toward prediction and explanation (for additional discussion of these issues, see Plomin, DeFries, & Fulker, 1988).

HOW SIMILAR ARE SIBLINGS IN PERCEIVED COMPETENCE? UNIVARIATE SIBLING ANALYSIS

A methodological issue that must be raised in relation to sibling correlations is that relatively large numbers of sibling pairs are required for adequate statistical power (Cohen, 1988). For example, with only 25 pairs of siblings, a sibling correlation would need to be .34 to be detected as statistically significant ($p < .05$, one-tailed because we are testing for positive sibling resemblance). A correlation of nearly .50 is required for 80%

power, that is, providing the ability to detect a true correlation of that magnitude four out of five times. More reasonable is a sample size of 50 pairs, with which a sibling correlation of .24 will be statistically significant and one of .35 will provide 80% power. Of course, from a statistical point of view, bigger sample sizes are definitely better.

In behavioral genetics, a special kind of correlation called an intraclass correlation is employed. The usual Pearson product-moment correlation is an interclass correlation in that it assumes that there are two distinct variables. This is not the case for the relationship between siblings for a single variable. The intraclass correlation takes into account all possible pairings of siblings within a family and is calculated using analysis of variance to compare variance between families (i.e., between sibling pairs) to total variance (i.e., variance within sibling pairs plus variance between sibling pairs). However, if in each family one sibling is randomly assigned to one arbitrary "class" and the other sibling to the other arbitrary "class," and then the usual interclass correlation is computed, this interclass correlation will be very similar to the intraclass correlation.

Substantial sibling resemblance can be expected because researchers have assumed that perceived competence largely depends on family environment (Wylie, 1979). An unstated implication of this emphasis on family environment is that siblings growing up in the same family should be similar in terms of perceived competence. Given the extent of genetic influence on personality, psychopathology, and cognitive abilities, it seems likely that genetic factors contribute to individual differences in perceived competence. Behavioral genetic research on this topic is especially timely given recent criticism that behavioral genetic researchers have not investigated domains such as perceived competence, which are thought to be due to nurture rather than nature (Hoffman, 1991).

By studying only one child per family, researchers have made the implicit assumption that environmental influences that contribute to perceived competence occur between families. Differences within families have been left unexplored. The use of siblings makes it possible to disentangle familial influences shared by siblings from those specific to each child (Reiss, 1993).

The first sibling studies of perceived competence have been reported for teacher, parent, and self ratings in adolescence (McGuire, Neiderhiser, Reiss, Hetherington, & Plomin, 1994; Neiderhiser, McGuire, Plomin, Hetherington, & Reiss, 1995) and

for teacher and parent ratings in middle childhood (Neiderhiser & McGuire, 1994). These reports come from the Nonshared Environment in Adolescent Development (NEAD) project (Reiss, et al., 1994) and the Colorado Adoption Project (CAP; DeFries, Plomin, & Fulker, 1994; Plomin et al., 1988).

NEAD includes 720 families with same-sex sibling pairs no more than 4 years apart in age, ranging from 10 to 18 years. There were approximately equal numbers of male and female sibling pairs. Six types of siblings were studied in two types of families—never-divorced families and stepfamilies. The never-divorced families included 93 monozygotic twin pairs, 98 dizygotic twin pairs, and 93 full sibling pairs. Stepfamilies included 180 full sibling pairs, 108 half sibling pairs, and 130 unrelated sibling pairs. Never-divorced families with full siblings were obtained through random-digit dialing of 10,000 telephone numbers throughout the United States. Most twin families and stepfamilies were recruited through national market panels of 675,000 households. The families were primarily middle class (average family income was $25,000–$35,000) and of European ancestry (94% of mothers and 93% of the fathers were Caucasian).

CAP is a longitudinal adoption design begun in 1975 that includes 245 children adopted in the first few weeks of life, their adoptive and biological parents, and a matched control group of 245 nonadoptive parents and children. Younger siblings in these families were also included in order to provide a sibling adoption design that compares genetically related siblings (nonadoptive siblings) and genetically unrelated siblings (adoptive siblings). Biological parents were solicited through two Denver adoption agencies. The majority of biological mothers and approximately 20% of biological fathers were typically tested during the last trimester of the mother's pregnancy. Following the birth of the child, biological mothers who chose to relinquish the child for adoption had no further contact with the child after leaving the hospital. Adoptive parents were asked to participate after the adoption was finalized. Nonadoptive families were recruited through local hospitals. Nonadoptive parents who expressed interest in the project were selected on the basis of matching an adoptive family with the following criteria: gender of the target child, number of children in the family, age of father, occupational status of father, and total years of father's education. After a match between adoptive and nonadoptive families was made, nonadoptive couples were invited to participate in the same 3-hour testing program administered to the

adoptive and biological parents. Nearly 90% of the biological parents and more than 95% of the adoptive and nonadoptive parents were Caucasian; the rest were primarily Hispanic and Asian. In general, the sample was found to be representative of the suburban Denver area. The adopted and nonadopted children, their siblings, and the home environment were assessed yearly from 1 year following the initial evaluation through middle childhood, with ongoing testing through adolescence.

Table 4.1 presents NEAD sibling correlations for perceived self-competence for adolescent full siblings in stepfamilies and in never-divorced families (McGuire et al., 1994). Full siblings are first-degree relatives whose coefficient of genetic relatedness is .50 as a result of sharing the same biological mother and father. Perceived competence and self-worth were assessed using Harter's (1988) Self-Perception Profile for Adolescents, omitting the scales of job competence and romantic appeal. Age and gender differences can inflate sibling correlations because siblings are close in age and some pairs are of the same gender. For perceived self-competence, gender and age effects were small. Nonetheless, in order to prevent any effect on sibling correlations, scores were corrected for age, gender, and gender-by-age interaction effects (McGue & Bouchard, 1984).

TABLE 4.1 UNIVARIATE SIBLING ANALYSIS: NEAD ADOLESCENT SIBLING INTRACLASS CORRELATIONS IN NEVER-DIVORCED FAMILIES AND IN STEPFAMILIES FOR HARTER'S (1988) SELF-PERCEPTION PROFILE FOR ADOLESCENTS

	Sibling Intraclass Correlations	
	Never-divorced Families (N = 94 pairs)	Stepfamilies (N = 179 pairs)
Scholastic	.29*	.15*
Athletic	.14	.06
Social	.07	.12
Physical Appearance	.08	.09
General Self-Worth	−.02	.09
Morality	.22*	.15*
Friendship	.12	.10

*$p < .05$.

Note. Adapted from "Genetic and Environmental Influences on Perceptions of Self-worth and Competence in Adolescence: A Study of Twins, Full Siblings, and Step Siblings," by S. McGuire, J. M. Neiderhiser, D. Reiss, E. M. Hetherington, & R. Plomin, 1994, *Child Development*. Copyright by Society for Research in Child Development. Reprinted by permission.

The sibling intraclass correlations in Table 4.1 indicate that siblings growing up in the same family are not very similar in their perceived self-competence. Although the scholastic and morality scales yield significant sibling correlations, the magnitudes of the correlations are quite low. The pattern of results is generally similar for siblings in never-divorced families and stepfamilies, although the magnitude of sibling correlations is somewhat lower in stepfamilies.

It should be mentioned that sibling correlations such as these directly index the extent to which variance covaries within sibling pairs, not the correlation squared. Correlations are squared in order to estimate the variance of one variable that can be predicted by another variable. Although one might wish to ask how much much of the variance of siblings' scores can be predicted by the co-siblings' scores, the issue at hand is the extent to which variance of siblings' scores covaries within pairs of siblings. The sibling correlation itself rather than the squared correlation addresses this issue.

Table 4.1 indicates that only about a quarter of the variance of the scholastic and morality scales covary for siblings. For the other scales, less than 10% of the variance covaries within pairs of siblings. Thus, these sibling data lead to the conclusion that siblings growing up in the same family are quite different in their perceived self-competence. Because the NEAD study included identical (MZ) and fraternal (DZ) twins, half-siblings, and unrelated siblings in addition to full siblings, it was possible to disentangle sibling resemblance due to shared heredity and shared family environment. The results of model-fitting analyses clearly indicated that the modest sibling resemblance observed in Table 4.1 is due to shared heredity, not to shared family environment (McGuire et al., 1994).

In CAP, Harter's (1982) Self-Perception Profile was administered to each sibling during a telephone interview when the child was 9 and again when he or she was 10 years of age. Sibling resemblance was determined by correlating the older sibling's assessment at 9 years old with that of the younger sibling at the age of 9; the same was done for the older and younger siblings' assessments at age 10. Comparisons of the children's self-perceptions at the same age controls for disparities that could arise from developmental differences between siblings of different ages. CAP sibling correlations at 9 and 10 are presented in Table 4.2 for a small sample of nonadoptive siblings. Similar to the NEAD results, sibling resemblance was greatest

TABLE 4.2 UNIVARIATE SIBLING ANALYSIS: CAP SIBLING INTRACLASS CORRELATIONS AT 9 YEARS AND 10 YEARS OF AGE FOR HARTER'S (1982) SELF-PERCEPTION PROFILE

	Sibling Intraclass Correlations	
	9 Years (N = 48 pairs)	10 Years (N = 33 pairs)
Scholastic	.41*	.22
Athletic	.06	.20
Social	−.13	.10
Physical Appearance	.39*	−.07
General Self-Worth	.29*	.08
Morality	−.01	.08

*$p < .05$.

Note. Adapted from "Competence During Middle Childhood," by J. M. Neiderhiser & S. McGuire, *Nature and Nurture During Middle Childhood*, edited by J. C. DeFries, R. Plomin, & D. W. Fulker, 1994, Cambridge, MA: Blackwell. Copyright by Blackwell. Reprinted with permission.

for perceptions of scholastic competence. Because CAP also includes adoptive siblings (pairs of genetically unrelated children adopted into the same family), it was possible to estimate the genetic contribution to the modest sibling resemblance. As in the NEAD project, model-fitting genetic analyses in CAP indicate that the familial resemblance is due solely to shared heredity rather than shared family environment (Neiderhiser & McGuire, 1994).

In contrast to the NEAD results, the morality scale in CAP showed no significant sibling resemblance at 9 or 10 years. Although this may be due to cohort effects, differences between samples (e.g., adoptive vs. stepfamilies), or small sample sizes, a more interesting possibility is that this finding represents an increase in familial influence from middle childhood (CAP) to adolescence (NEAD) for this dimension of perceived self-competence. Such developmental sibling comparisons are the topic of the following section. Another interesting developmental aspect of the CAP results is the decline in sibling resemblance from 9 to 10 years of age for the physical appearance scale and the general self-worth scale. Further research is needed to follow up on this possible developmental trend as children move from middle childhood to early adolescence.

Similar NEAD results were obtained using Harter's (1982) Teacher's Rating Scale of Actual Behavior (Neiderhiser et al.,

TABLE 4.3 UNIVARIATE SIBLING ANALYSIS: NEAD SIBLING INTRACLASS CORRELATIONS IN NEVER-DIVORCED AND IN STEPFAMILIES FOR HARTER'S (1982) TEACHER'S RATING SCALE OF ACTUAL BEHAVIOR

	Sibling Intraclass Correlations	
	Never-divorced Families (N = 46 pairs)	Stepfamilies (N = 74 pairs)
Cognitive Competence	.21	.35*
Social Competence	.06	.21

*$p < .05$.

Note. Adapted from *Teacher Ratings of Cognitive and Social Competence of Adolescents: Genetic as well as Environmental Influences*, by J. M. Neiderhiser, S. McGuire, R. Plomin, E. M. Hetherington, & D. Reiss, 1995, manuscript submitted for publication. Reprinted with permission.

1995). Two teachers were nominated by each child during interviews in the home. Each teacher who was nominated was asked to complete the teacher questionnaire and to return it to us by mail. Sibling correlations for the cognitive and social competence scales, the two competence scales for which teachers indicate confidence in their ratings (Harter, 1982), are shown in Table 4.3. For full siblings in both never-divorced and stepfamilies, modest sibling resemblance was found for cognitive competence, and even less sibling resemblance was found for social competence. Similar to the results for self-ratings, genetic model-fitting analyses that included all of the NEAD sibling groups indicated that this modest sibling resemblance was due to shared heredity rather than shared environment (Neiderhiser et al., 1995).

Mother ratings of social competence were also obtained in CAP when the children were 7 years old, using a measure derived from the Walker–McConnell Scale of Social Competence (Walker & McConnell, 1988). Teacher ratings on a similar measure were obtained for the siblings, on average about 2 years apart, when each sibling was 7 years old and again when each sibling was 9 years old. Again, the older and younger siblings' age 7 assessments were correlated with each other to determine sibling resemblance, as were their age 9 assessments. Sibling correlations for these measures are listed in Table 4.4. Maternal ratings for popularity and confidence yielded significant sibling correlations, but not for leadership. Teacher ratings made when each sibling was 7 years old yielded significant sibling resemblance for all three dimensions, even though the two children were rated on average 2 years apart and usually by differ-

TABLE 4.4 UNIVARIATE SIBLING ANALYSIS: CAP SIBLING INTRACLASS CORRELATIONS FOR MOTHER RATINGS AT 7 YEARS AND TEACHER RATINGS AT 7 AND 9 YEARS ON SOCIAL COMPETENCE SCALES

	Sibling Intraclass Correlations	
	7 Years (N = 55 pairs)	9 Years (N = 38 pairs)
Maternal Ratings		
Popularity	.29*	—
Confidence	.41*	—
Leadership	.10	—
Teacher Ratings		
Popularity	.36*	.16
Confidence	.42*	.26
Leadership	.37*	.30*

*$p < .05$.

Note. Adapted from "Competence During Middle Childhood," by J. M. Neiderhiser & S. McGuire, *Nature and Nurture During Middle Childhood*, edited by J. C. DeFries, R. Plomin, & D. W. Fulker, 1994, Cambridge, MA: Blackwell. Copyright by Blackwell. Reprinted with permission.

ent teachers. From a developmental perspective, the decrease in sibling correlations from 7 to 9 years for teacher ratings of social competence, suggests the possibility of a diminished role for familial influences in early adolescence.

WHY ARE SIBLINGS SO DIFFERENT? NONSHARED SIBLING ANALYSIS

As in most other domains of development (Dunn & Plomin, 1990; Plomin, Chipuer, & Neiderhiser, 1994), siblings growing up in the same family are quite different in terms of perceived competence. Sources of sibling differences are called *nonshared* because they are not shared by children growing up in the same family, thus making siblings different rather than similar.

One direction for research in this area is to identify specific nonshared environmental factors by examining differential experiences of siblings. For example, are differential experiences of siblings related to differences in their perceived self-competence? Rather than investigating socialization correlates on a family-by-family basis—which is typically done (Wylie, 1979)—

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sibling *differences* in perceived self-competence can be related to differential experiences of siblings. The point of such nonshared environmental analyses is to find those influences that are specific to each child within a family, because such nonshared influences are most important for the development of individual differences for all children, not just for siblings. Identifying specific sources of nonshared environment is the goal of the NEAD project (Reiss et al., 1994). Some success has been achieved for antisocial behavior and depression (Reiss et al., in press). However, no attempt has previously been made to identify environmental correlates of sibling differences in perceived self-competence.

This question can be addressed in several ways. In NEAD, initial work has focused on two major models. One model uses a regression approach that identifies aspects of one sibling's experiences that are related to that sibling's outcomes independent of the other sibling's experiences (Reiss et al., in press). The second model is a simple differences model in which differences in sibling experiences are related to differences in sibling outcomes (Pike, Hetherington, Reiss, & Plomin, 1995). As an example of the differences model, we examined associations between sibling differences in perceived self-competence and sibling differences in major composites of parenting. Using NEAD data from full siblings in never-divorced families and stepfamilies, relative sibling differences were calculated by subtracting the younger sibling's score from the older sibling's score on each of the perceived self-competence scales and on three major composites of parenting (positive, negative, control). The parenting composites were derived from factor analyses of various questionnaire measures that yielded similar factor structures for child reports and parent reports (Plomin, Reiss, Hetherington, & Howe, 1994).

Table 4.5 presents correlations between differential experiences as assessed by child and parent reports on the three composite measures of parenting and sibling differences for a single Harter scale of perceived self-competence: general self-worth. Siblings' differences in their perceptions of their parents' positive and negative aspects of parenting are related to differences in their perceptions of general self-worth. Within sibling pairs, the sibling with higher perceived worth also perceived more positive and less negative parenting. Sibling differences in perceived self-worth were not related to perceptions of parental differences in control. Results were similar for never-

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TABLE 4.5 NONSHARED SIBLING ANALYSIS: CORRELATIONS BETWEEN RELATIVE SIBLING DIFFERENCES IN PERCEIVED SELF-COMPETENCE (GENERAL SELF-WORTH) AND PARENTING IN NEAD

Relative Sibling Differences for Parenting	Correlations with Siblings' Relative Differences in Perceived General Self-Worth	
	Never-divorced Families (N = 93 pairs)	Stepfamilies (N = 181 pairs)
Child Ratings of Mother		
Positive	.26*	.25*
Negative	−.20	−.20*
Control	−.01	.00
Child Ratings of Father		
Positive	.15	.26*
Negative	−.17	−.22*
Control	−.01	.11
Mother Ratings		
Positive	.03	.08
Negative	−.14	−.15
Control	−.10	.11
Father Ratings		
Positive	.04	.10
Negative	−.13	−.03
Control	−.07	.08

*$p < .05$.
Note. Unpublished data.

divorced families and stepfamilies. A rater effect appears to operate in that correlations were lower when differences in sibling perceptions of self-worth were correlated with differences in parental perceptions of parenting rather than siblings' own perceptions of parenting, as shown in the second half of Table 4.5. Results for the other Harter scales were generally similar.

Siblings can also be used to identify nonshared behavioral correlates, such as temperamental differences, that might be related to differences in perceived self-competence. Again, NEAD data from full siblings in never-divorced families and stepfamilies were used as an example. Table 4.6 presents correlations between sibling differences in parental ratings of temperament and sibling differences in the general self-worth scale of Harter's perceived self-competence measure in NEAD. Child temperament was assessed using the EAS Temperament Survey-Parent Form (Buss & Plomin, 1984), a 20-item questionnaire that assesses four dimensions of temperament: emotionality, activity level, sociability, and shyness.

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TABLE 4.6 NONSHARED SIBLING ANALYSIS: CORRELATIONS BETWEEN RELATIVE SIBLING DIFFERENCES IN PERCEIVED SELF-COMPETENCE (GENERAL SELF-WORTH) AND PARENTAL RATINGS OF TEMPERAMENT IN NEAD

Relative Sibling Differences for Temperament	Correlations with Siblings' Relative Differences in Perceived General Self-Worth	
	Never-divorced Families (N = 93 pairs)	Stepfamilies (N = 181 pairs)
Mother Ratings		
Emotionality	−.25*	−.04
Activity	.22*	.15*
Sociability	.02	.23*
Shyness	−.09	−.21*
Father Ratings		
Emotionality	−.26*	−.08
Activity	.34*	.15*
Sociability	.31*	.14
Shyness	−.19	−.21*

*$p < .05$.
Note. Unpublished data.

Sibling differences in perceived general self-worth are related to sibling differences in temperament as rated by parents. As expected, the sibling with higher perceived self-worth is rated more positively by both mothers and fathers—that is, as less emotional, more active, more sociable, and less shy. It is interesting but puzzling that for both mother and father ratings of the siblings' emotionality, the correlations with perceived self-worth are lower in stepfamilies than in never-divorced families. Otherwise, results are generally similar for the two types of families; results are also similar for the other Harter scales.

DOES SIBLING RESEMBLANCE IN COMPETENCE CHANGE DURING PUBERTY? DEVELOPMENTAL SIBLING ANALYSIS

Although the earliest twin studies focused on age differences in twin resemblance (Merriman, 1924; Thorndike, 1905), interest in developmental issues virtually disappeared until the past decade (Plomin, 1986). Developmental sibling analyses include two major categories: cross-sectional or longitudinal compar-

isons of familial influence as a function of age, and longitudinal analysis of continuity and change from age to age.

Sibling correlations can be examined as a function of age in order to explore developmental differences in familial influence. Several examples of possible developmental change in familial influence on competence were noted earlier. For instance, comparisons between the CAP data in middle childhood and the NEAD data in adolescence suggested increases in familial resemblance from childhood to adolescence for the morality scale of the perceived self-competence measure. In addition, the CAP data, which permit longitudinal comparisons for the same sample, suggest a decrease in familial resemblance from 9 to 10 years for perceived self-competence on the physical appearance scale and the general self-worth scale. A third example of possible developmental change in familiality emerged from the analyses of teacher ratings at 7 and 9 years in CAP. Although the sibling sample sizes are small and the findings need to be replicated, the results suggest a decline in familial influence from 7 to 9 years for teacher ratings of competence. This might be another example of siblings "growing up and growing apart" (McCartney, Harris, & Bernieri, 1990).

A more general use of this type of developmental sibling analysis is to compare sibling resemblance cross-sectionally as a function of age within a single study. One approach is to treat age as a continuous measure and to ask whether sibling resemblance interacts with age using a hierarchical multiple regression approach described elsewhere (Ho, Foch, & Plomin, 1980). When age is continuously distributed within a study, it is seldom appropriate to divide the sample at some median age and to compare sibling correlations for younger and older siblings. However, such group comparisons are appropriate when the sample is divided in terms of a discontinuous marker such as before and after the transition to school or pre- and postpuberty. For example, the NEAD sample is nearly equally divided into children who are prepubertal, midpubertal, and postpubertal. Using mothers' reports of children's pubertal status, we selected sibling pairs in which both siblings were prepubertal or just beginning puberty and those sibling pairs in which both siblings were in advanced puberty or postpubertal, combining never-divorced families and stepfamilies in order to increase the sample size. This resulted in 34 prepubertal pairs and 90 postpubertal pairs.

Using this biological index of development, we can ask whether sibling resemblance differs for pairs in which both siblings are

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TABLE 4.7 DEVELOPMENTAL SIBLING ANALYSIS: NEAD ADOLESCENT SIBLING INTRACLASS CORRELATIONS FOR PREPUBERTAL AND POSTPUBERTAL PAIRS USING HARTER'S (1988) SELF-PERCEPTION PROFILE FOR ADOLESCENTS

	Sibling Intraclass Correlations	
	Prepubertal Siblings (N = 34 pairs)	**Postpubertal Siblings (N = 90 pairs)**
Scholastic	.24*	.19*
Athletic	.15	−.02
Social	.29*	.07
Physical Appearance	.32*	−.03
General Self-Worth	.30*	−.04
Morality	.11	.20*
Friendship	.25*	.13

*$p < .05$.
Note. Unpublished data. Full siblings in never-divorced and stepfamilies have been pooled for this analysis.

prepubertal and those in which both siblings are postpubertal. Table 4.7 presents sibling correlations for perceived self-competence in NEAD for prepubertal and postpubertal sibling pairs. The developmental comparisons presented earlier suggest that if sibling resemblance changes during development it declines. The results, for the most part, support this hypothesis. Except for morality, the results for all subscales suggest that sibling resemblance declines from prepubertal to postpubertal status, although none of the correlations are significantly different; this leaves open the possibility that these differences are due to chance variation. Nonetheless, as they stand, these results suggest the hypothesis that familial influences on perceived self-competence, especially for physical appearance and general self-worth, may decline in impact from prepuberty to postpuberty.

A second type of developmental sibling analysis addresses familial contributions to age-to-age continuity and change. This sibling analysis requires longitudinal data. The analysis rests on cross-sibling correlations in which one sibling's score at one age is correlated with the other sibling's score at the other age. The upper limit for such cross-sibling correlations is the longitudinal correlation for individuals. Cross-sibling correlations assess the extent to which familial factors are responsible for the longitudinal correlations.

Table 4.8 presents CAP longitudinal cross-sibling correlations from 9 to 10 years for self-ratings of competence and from 7 to

TABLE 4.8 DEVELOPMENTAL SIBLING ANALYSIS: CAP LONGITUDINAL CROSS-SIBLING CORRELATIONS FROM 9 TO 10 YEARS FOR SELF-RATINGS AND FROM 7 TO 9 YEARS FOR TEACHER RATINGS OF COMPETENCE

Measure	Longitudinal Stability Correlation (N = 130 pairs)	Longitudinal Cross-Sibling Correlation (N = 33 pairs)
Perceived Self-Competence		
Scholastic	.40*	.33*
Athletic	.31*	.11
Social	.37*	.08
Physical Appearance	.47*	.13
General Self-Worth	.29*	.05
Morality	.37*	.05
Teacher Ratings		
Popularity	.37*	.35*
Confidence	.38*	.16
Leadership	.45*	.37*

*$p < .05$.
Note: Unpublished data.

9 years for teacher ratings, combining adoptive and nonadoptive siblings. Two cross-sibling correlations could be presented: one for the younger sibling at age 7 versus the older sibling at age 9, and the other for the younger sibling at 9 versus the older sibling at 7. However, a technique often used in behavioral genetics is called *double entry*, which means entering the siblings twice with their order reversed. That is, if the array of younger siblings is A and the array of older siblings is B, instead of simply correlating A with B, we enter A followed by B, and we enter B followed by A. When the A–B array is correlated with the B–A array, this double-entry procedure approximates an intraclass correlation of all possible pairings of A and B, as discussed earlier.

Table 4.8 presents cross-sibling intraclass correlations using this double-entry procedure. Longitudinal correlations for all individuals are also included in Table 4.8 for purposes of comparison because, as mentioned earlier, longitudinal correlations create an upper limit for cross-sibling longitudinal correlations. For self-ratings of scholastic competence and for teacher ratings of popularity and leadership, the cross-sibling correlations are significant, and they are nearly as great as the longitudinal correlations. This suggests that most of the stability from age to age for these dimensions can be accounted for by familial factors. Longitudinal genetic model-fitting analyses of these

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data, which compare adoptive and nonadoptive siblings, indicate that genetic factors are largely responsible for this familially mediated continuity (Neiderhiser & McGuire, 1994). Cross-sibling correlations that are much lower than the comparable longitudinal correlations, as is the case for the other competence dimensions, suggest that familial factors do not play a major role in continuity. Longitudinal genetic model-fitting analyses indicate that nonshared environmental factors (which include chance idiosyncratic experiences) play an important role in the continuity of these dimensions of self-competence (Neiderhiser & McGuire, 1994).

This analysis focuses on continuity, the extent to which familial factors are responsible for longitudinal stability. What about change? Adolescence is a peak period for change in self-competence (Damon & Hart, 1982; O'Malley & Bachman, 1983), as indicated by the modest longitudinal correlations from age to age shown in Table 4.8. A simple sibling analysis of developmental change employs age-to-age change scores. Sibling correlations can be calculated for these change scores to ask whether siblings change in similar directions and to a similar extent from age to age.

As an example, we calculated relative change scores for CAP children from 9 to 10 for their perceived self-competence and from 7 to 9 for teacher ratings of their competence. Because we created change scores by subtracting Age 1 scores from Age 2 scores, these are relative change scores. Some change scores were positive, indicating that competence increases from Age 1 to Age 2; and some differences scores were negative, indicating declines in competence. Table 4.9 lists intraclass correlations for these change scores. Changes in the siblings' perceptions of general self-worth and teacher ratings of confidence suggest some familial influence, although these correlations are not significant given the small sample size. For the other scales, the low and even negative correlations suggest that familial factors are not importantly involved in change in competence from age to age. That is, whatever causes children to change in their perceived self-competence or in teacher ratings of their competence, these agents of change are not shared by children growing up in the same family.

Although these preliminary developmental sibling analyses of self-competence raise many more questions than answers, they provide a glimpse of the exciting possibilities for charting the developmental course of familial influence using sibling data.

TABLE 4.9 DEVELOPMENTAL SIBLING ANALYSIS: CAP SIBLING CORRELATIONS FOR CHANGE SCORES FROM 9 TO 10 YEARS FOR SELF-RATINGS AND FROM 7 TO 9 YEARS FOR TEACHER RATINGS OF COMPETENCE

Measure	Sibling Intraclass Correlation for Change Scores (N = 33 pairs)
Perceived Self-Competence	
Scholastic	−.15
Athletic	.08
Social	−.23
Physical Appearance	.12
General Self-Worth	.23
Morality	.02
Teacher Ratings	
Popularity	−.19
Confidence	.25
Leadership	−.05

*$p < .05$.
Note. Unpublished data.

DO FAMILIAL EFFECTS ON COMPETENCE OVERLAP WITH OTHER MEASURES? MULTIVARIATE SIBLING ANALYSIS

In contrast to univariate sibling analyses that assess the familial contribution to the variance of a single variable, multivariate sibling analyses address the covariance between variables. For example, multivariate sibling analyses can be used to explore the antecedents and consequences of familial influence on perceived self-competence. Questions concerning antecedents include the extent to which sibling similarity in competence is due to sibling similarity in cognitive ability or personality. Multivariate sibling analyses can also address familial overlap in consequences or outcomes. For example, to what extent do sibling similarities and differences in perceived self-competence overlap with sibling similarities and differences in depression?

NEAD provides several examples of multivariate sibling analyses. One example involves correlates of cognitive competence. As shown in Table 4.3, teacher ratings of cognitive competence yield modest sibling correlations. To what extent is this due to familial resemblance in cognitive ability? Although IQ is not as-

sessed in NEAD, vocabulary is included in the study. Vocabulary loads highly on a factor of general cognitive ability and is therefore appropriate for the present purpose.

Teacher reports of cognitive competence correlate .25 with tested vocabulary in NEAD. To what extent is this phenotypic correlation mediated by familial factors that overlap in their effect on cognitive competence and vocabulary? Cross-sibling correlations, described in the previous section, can be used to address this multivariate question. In a double-entry format, teacher ratings of cognitive competence for one sibling can be correlated with the vocabulary score of the other sibling. The cross-sibling correlations for full siblings in NEAD are .36 for the 48 sibling pairs in never-divorced families and .23 for the 78 sibling pairs in stepfamilies. Both cross-sibling correlations are significant and similar in magnitude to the phenotypic correlation of .25 between teacher ratings of cognitive competence and vocabulary. This finding suggests that the phenotypic correlation between cognitive competence and vocabulary is mediated entirely by familial factors. That is, the familial factors that contribute to teacher ratings of cognitive competence overlap completely with familial factors that affect vocabulary. A multivariate genetic analysis that included all six sibling groups in NEAD indicated that genetic factors are responsible for familial influences that overlap in their effect on cognitive competence and vocabulary (Neiderhiser et al., 1995). Other NEAD multivariate genetic analyses also point to genetic overlap between self-perceived scholastic competence and vocabulary and between self-perceived social competence and sociability (McGuire et al., 1994).

The reason why this multivariate sibling analysis focused on the familial contribution to covariation between competence and cognitive ability is that these two measures are correlated phenotypically. In many cases, however, domains of interest are not correlated. For example, teacher ratings of social competence correlate only .14 with adolescents' self-ratings of sociability (Neiderhiser et al., 1995). The familial contribution to this covariance is too small to detect with reasonable sample sizes because the phenotypic covariance itself is so small. A more appropriate question is the extent to which sibling differences in competence are due to sibling differences in temperament. For example, using the full siblings from the NEAD data set, we created relative sibling difference scores for teacher reports of social competence and for adolescents' self-reports of sociability. The correlation between these two difference scores was only

.10 in never-divorced families (N = 46 pairs) and .17 in stepfamilies (N = 76 pairs). This finding suggests that sibling differences in social competence are not much related to sibling differences in sociability.

A final example of the usefulness of multivariate sibling analyses involves cross-rater overlap. Teacher, parent, and self-reports of competence correlate modestly. To what extent do these various sources of information involve the same underlying familial factors? For example, do the familial effects on teacher ratings of competence overlap with familial effects on parent ratings and self-ratings? For the entire NEAD sample, teacher reports of cognitive competence correlate .37 with mother reports, .33 with father reports, and .39 with self-reports. Table 4.10 presents cross-sibling correlations between teacher reports and parent and self-reports. The cross-sibling correlations are on average about half the magnitude of the phenotypic correlations. This suggests that familial factors in part overlap in their effect on teacher ratings as compared to parent and self-ratings. In part, however, familial influences are unique to teacher ratings. In other words, they are independent of parent and self-ratings. This implies that teachers see aspects of competence that are etiologically different from competence as perceived by parents and by adolescents themselves. Multivariate genetic analyses of these data using all six of the NEAD sibling types indicate that most of the familial overlap among competence ratings by teachers, parents, and

TABLE 4.10 MULTIVARIATE SIBLING ANALYSIS: NEAD PHENOTYPIC CORRELATIONS AND CROSS-SIBLING CORRELATIONS COMPARING TEACHER RATINGS OF COGNITIVE COMPETENCE TO PARENT RATINGS AND SELF-RATINGS

	Correlations with Teacher Ratings of Cognitive Competence		
Measure of Cognitive Competence	**Phenotypic Correlation (N = 664)**	**Cross-Sibling Correlation Never divorced (N = 48)**	**Step (N = 78)**
Mother Report	.37*	.00	.10
Father Report	.33*	.16	.12
Self-Report	.39*	.29*	.13

*$p < .05$.

Note. Adapted from *Teacher Ratings of Cognitive and Social Competence of Adolescents: Genetic as well as Environmental Influences*, by J. M. Neiderhiser, S. McGuire, R. Plomin, E. M. Hetherington, & D. Reiss, 1995, manuscript submitted for publication. Reprinted with permission.

adolescents is genetically mediated. Despite this, substantial genetic influence on teacher ratings of competence are unique to teacher ratings; that is, some of these genetic effects are not shared in common with competence ratings by parents or adolescents (Neiderhiser et al., 1995).

In summary, multivariate sibling analyses have many potential applications for the exploration of links between measures, which is at the heart of such fundamental issues as heterogeneity and comorbidity in developmental psychopathology (Plomin & Rende, 1991). The benefit of multivariate sibling analyses is that they take into consideration these issues not only at the phenotypic level of analysis, but also at the etiological level of familial influence.

LINKS BETWEEN THE NORMAL AND ABNORMAL—DF SIBLING ANALYSIS

Finally, sibling research can be employed to address one of the most important questions in developmental psychopathology: the etiological links between the normal and abnormal. The word *etiological* is important here. The issue is not whether the phenotypic distribution of behavioral variation is continuous. Rather, the question is the extent to which developmental influences on behavioral problems of childhood are merely the extremes of influences in the normal range. That is, is psychopathology nothing more than the quantitative extreme of a continuous distribution of genetic and environmental influences? Or are genetic and environmental influences on abnormal behaviors qualitatively distinct from those that affect the normal range of variation? Sibling research can explore the extent to which familial factors for abnormal behavior are merely quantitatively extreme versions of familial factors responsible for the normal range of behavioral variation.

For example, are the familial factors involved in the normal range of variation in competence the same familial factors responsible for extremely low competence? If the answer is "no," it would imply that extremely low competence is etiologically different from variation in competence in the normal range. If the answer is "yes," it would imply that extremely low competence is nothing but the low end of the etiological factors responsible for the normal distribution of competence. In other

words, if the latter were the case, it suggests that children low in competence are only quantitatively, not qualitatively, different from children higher in competence.

A new behavioral genetic analysis makes it possible to broach this fundamental issue of the etiological association between the normal and abnormal (DeFries & Fulker, 1985, 1988). This method has been called DF analysis after its developers, DeFries and Fulker (Plomin & Rende, 1991). DF analysis leads to an estimate of what is called group familiality, in contrast to the usual familiality, estimated, for example, by a sibling correlation, which could be called individual familiality. Individual familiality refers to the contribution of familial factors to the origins of individual differences for a trait. In contrast, group familiality refers to the familial contribution to the average difference on a quantitative measure between a selected group, such as an extreme group, and the rest of the population. DF analysis assesses group familiality as the regression toward the population mean of the siblings of probands (i.e., selected index cases) for a quantitative measure.

For example, teacher ratings of cognitive competence show individual familiality, as indicated in Tables 4.3 and 4.4. To what extent is low cognitive competence also influenced by familial factors? This question addresses the etiology of the average difference between children low in teacher-rated cognitive competence and the rest of the population. It does not ask about familial contributions to individual differences among children low in competence. That is, the question as to why one child low in teacher-rated competence has a slightly lower score than another low-competence child is relatively unimportant compared to the question as to why, as a group, children rated low in competence differ from the rest of the population. The causes of individual differences could well differ from the causes of average differences between groups. For example, for IQ, severe retardation shows no group familiality, whereas mild retardation shows substantial group familiality (Plomin, 1991). In terms of the low end of the dimension of competence, family factors may play a more (or less) important role than they do for individual differences for the entire distribution of competence.

If we select children who are low in teacher-rated competence, we would expect the competence scores of their siblings to regress somewhat toward the population mean. However, to the extent that familial factors are important in the etiology of

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the average difference between the low-competence group and the population, the competence scores of the siblings of the low-competence probands will not regress as far to the population mean. For example, the IQ scores of siblings of severely retarded individuals are similar to the population average of 100, whereas the IQ scores of siblings of mildly retarded individuals are much lower than the population average (Plomin, 1991). This suggests that group familiality occurs for mild retardation but not for severe retardation.

As an example of DF sibling analysis for competence, we selected children in the NEAD sample from the bottom 10% of teacher ratings of cognitive competence after pooling the full siblings in never-divorced and stepfamilies in order to increase the sample size. The typical approach in genetic research on disorders is to calculate concordance. That is, what percentage of the siblings of selected probands also meet the selection criterion? In the NEAD sample, 25 children (10%) met the criterion. Of these probands, six were in three concordant sibling pairs. The probandwise method for calculating concordance divides the number of affected siblings in concordant pairs (i.e., 6) by the number of probands (25). Thus, the probandwise concordance for low competence is .24. Probandwise concordance can be interpreted as a risk estimate: There is a 24% risk that the sibling of a proband identified as low in teacher-rated competence will also be rated low in competence.

The problem with concordance is that it treats quantitative information about competence as if it were qualitative. For this reason, DF analysis is superior in the analysis of dimensional (as opposed to diagnostic) data. In those cases where both members of a sibling pair met the criteria for the low-competence group, the data were double-entered so that each sibling served as a proband and a sibling. For the teacher-rated cognitive competence measure, the mean of the entire NEAD full sibling sample is 19.0. The probands, the lowest 10% of the distribution, had a mean competence score of 9.6. The siblings of the probands had a mean competence score of 16.3. Thus, the siblings of the low-competence probands had lower-than-average competence scores, indicating group familiality for low teacher-rated cognitive competence. An index of group familiality can be calculated from the mean scores for probands, siblings, and the population (Plomin, 1991). If scores are standardized, group familiality is merely the average of the sibling standardized scores divided by the mean proband score. The

group familiality estimate for the low-competence sample in NEAD is .26.

Thus, DF sibling analysis indicates that familial factors contribute to the etiology of low competence. An additional step in DF analysis is to compare group familiality to individual familiality in order to explore the etiological links between the normal and abnormal. If group familiality differs from individual familiality, low competence is different etiologically from the normal range of competence. On the other hand, if group familiality is similar to individual familiality, this suggests that low competence may be nothing more than the etiological extreme of the normal distribution of familial effects. As just mentioned, the estimate of group familiality for teacher-rated low cognitive competence is .26. For the same measure, individual familiality was estimated to be .28 on average, as indicated by the sibling correlations in Table 4.3. Thus, the group familiality and individual familiality estimates are similar. This suggests that familial factors responsible for low cognitive competence as rated by teachers are quantitatively, not qualitatively, different from those responsible for normal variability in this measure of competence. Results for other samples could of course differ. In particular, it should be noted that the NEAD sample is a nonclinical sample. These DF results for NEAD children in the lowest 10% of the distribution of competence scores might differ from those obtained from a sample, for example, of clinically depressed children.

In summary, when sibling data are obtained using quantitative measures in an unselected sample, they provide an opportunity to examine sibling resemblance, not just as a correlation for the entire sample, but also as a "group" correlation for an extreme group. Research using this new technique will greatly advance understanding of the etiological relationship between the normal and abnormal.

CONCLUSION

The message of this chapter is that the inclusion of siblings in research makes it possible to address important and novel behavioral genetic questions concerning the etiology of individual differences. We examined five types of sibling analyses. Univariate sibling analyses estimate the importance of shared fa-

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milial influences in development by assessing sibling resemblance. Univariate sibling analyses often indicate that siblings growing up in the same family are surprisngly different from one another. This leads to the second type of sibling analysis, nonshared sibling analysis, which asks why siblings are so different. Nonshared sibling analysis relates sibling differences on a target trait to sibling differences in experiences such as parental interactions or to sibling differences in other traits such as temperament.

The third set of sibling analyses is developmental in nature. Developmental sibling analyses include comparisons of sibling correlations as a function of age in order to investigate the extent to which the contribution of familial factors changes during development. Another type of developmental sibling analysis requires longitudinal data and assesses familial contributions to age-to-age continuity and change.

The fourth type of sibling analyses is multivariate. Multivariate sibling analyses investigate the extent to which familial factors that influence a target trait overlap in their effects on other traits. Such analyses have broad applications, for example, in analyzing heterogeneity and comorbidity in terms of familial etiology rather than symptomatology.

The fifth analysis, called DF sibling analysis, examines the familial links between the normal and abnormal. This analysis addresses the familial etiology of the average difference between a selected group, such as children with extreme scores or children who meet a diagnostic cut-off, and the rest of the population.

We provided examples of these sibling analyses in the domain of perceived competence, a domain that has only recently been examined using behavioral genetic strategies. Univariate sibling analyses consistently indicate significant shared familial influence for the scholastic dimension of perceived self-competence and teacher ratings of cognitive competence. Other dimensions of competence show less consistent patterns of familial influence.

As an example of nonshared sibling analyses, we examined associations between sibling differences in perceived self-competence and sibling differences in parenting. Within sibling pairs, siblings reporting higher perceived self-worth felt that their parents treated them more positively and less negatively than the parents treated their siblings. We also investigated associations between sibling diferences in perceived self-competence and sibling differences in parent-rated temperament.

Siblings with higher perceived self-worth were rated by their parents as less emotional, more active, more sociable, and less shy than were their siblings.

Several interesting results emerged from our developmental sibling analyses of perceived competence. In general, it appears that familial influence on competence declines in importance from middle childhood to adolescence, with the possible exception of the morality dimension of perceived self-competence. We presented new data on sibling resemblance for perceived self-competence as a function of pubertal status. It appears that sibling resemblance declines from pre- to postpuberty. In addition to investigating developmental changes in the magnitude of familial resemblance as assessed by sibling correlations, we used longitudinal cross-sibling correlations to explore familial contributions to age-to-age continuity. For self-reports of scholastic competence and for teacher ratings of popularity and leadership, familial factors appear to be responsible for most of the stability from age to age. For other dimensions of perceived self-competence, familial factors are not importantly involved in continuity. We also analyzed familial contributions to developmental change and found that familial factors, as assessed by sibling correlations for change scores, are not importantly involved in change in perceived self-competence or in teacher ratings of competence.

Three examples of multivariate sibling analyses were presented. We found that familial influences on teacher ratings of cognitive competence overlap completely with familial influences on vocabulary. That is, the same familial factors contribute both to cognitive competence and to vocabulary. We also analyzed sibling differences in teacher reports of social competence and adolescents' self-reports of sociability. The results indicated that sibling differences in social competence are not due to sibling differences in sociability. The third example of multivariate sibling analyses involved etiological overlap between teacher ratings of cognitive competence and parent and adolescent self-ratings. It appears that familial factors that affect teacher ratings of cognitive competence to some extent overlap with familial effects on parent and self-ratings. In part, however, teacher ratings assess aspects of cognitive competence that are etiologically different from competence as perceived by parents and by adolescents themselves.

Finally, as an example of DF sibling analysis, we investigated the extent to which low cognitive competence as rated by teach-

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ers is influenced by familial factors, as is the normal range of variation in teacher-rated cognitive competence. The results of DF sibling analysis suggested that familial factors responsible for low cognitive competence as rated by teachers are quantitatively, not qualitatively, different from those responsible for normal variability.

Numerous permutations of these sibling analyses are possible, and alternative analyses can be contemplated. Moreover, more elegant approaches to these analyses are available, such as model fitting. However, the goal of the chapter was not to provide an exhaustive description of sibling analyses relevant tc issues of behavioral genetics. Rather, our aim was to present a few simple and practical examples of such analyses in order to highlight the importance of incorporating siblings in future research.

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